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Working Paper

Issues in stability of European money demand: Adjustment speed versus error variance

Diskussionsbeiträge - Serie II, No. 356

Provided in Cooperation with:

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Suggested Citation: Läufer, Nikolaus K. A. (1997) : Issues in stability of European money demand: Adjustment speed versus error variance, Diskussionsbeiträge - Serie II, No. 356, Universität Konstanz, Sonderforschungsbereich 178 - Internationalisierung der Wirtschaft, Konstanz

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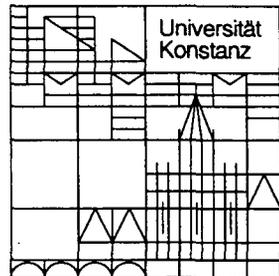
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**Sonderforschungsbereich 178
„Internationalisierung der Wirtschaft“**

Diskussionsbeiträge

Juristische
Fakultät

Fakultät für Wirtschafts-
wissenschaften und Statistik

Nikolaus K. A. Läufer

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Adjustment Speed
Versus Error Variance**

798031

W 113 (356)



D-78457 Konstanz

Serie II — Nr. 356
November 1997

19. DEZ. 1997 Wirtschaft
Kiel

W 113 (356)

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Issues in Stability of European Money
Demand: Adjustment Speed Versus
Error Variance

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*We thank the German Research Foundation for financial assistance (SFB 178).

Abstract

The current discussion about stability of the European money demand function is flawed by a confusion of two different concepts of stability (adjustment speed versus error variance). The meaning and importance of the underlying notions of stability is clarified. It is demonstrated that necessary and sufficient conditions for the two types of stability are mutually independent and empirical issues. The issues are related to a distinction between a *currency substitution* effect and a *portfolio diversification* effect. The difference can also be related to the choice between discretionary and rule-oriented monetary policies.

JEL code: E41, E52

Keywords: European Money Demand, Stability, Monetary Policy

1 Introduction

The hypothesis that an aggregate European money demand function is more stable than the underlying national money demand functions is by now well known. The discussion about this difference in stability is however flawed by a confusion of two different issues. Speaking of higher stability, some authors refer to a *higher speed of adjustment*¹ towards equilibrium in money holdings while others² refer to a lower variance (i.e. average size) of the underlying disequilibria. On the surface the two issues seem to be equivalent. After all, a higher speed for reaching equilibrium will lower the average size of observable disequilibria. Convincing as this simple idea may seem, it is rather misleading. The purpose of the following note is to show that there are two distinct and essentially independent concepts of stability. This is done by investigating the necessary and sufficient conditions for both kinds of stability. The types of stability have different implications and relevance for monetary policy depending on whether monetary policy is discretionary or rule-oriented.

In the literature³ the higher stability of the European money demand function has been explained by currency substitution. We shall demonstrate that, depending on the type of stability, currency substitution is either not necessary or not sufficient. In the case, where currency substitution is not necessary, the higher stability of the European money demand function may be explained by a "portfolio diversification effect" even if no individual and no country (aggregate of individuals) holds more than one currency. This view contrasts heavily with the position where portfolio diversification is considered to be a special case of currency substitution. It is also shown that this result is not implied by linear aggregation theory.

The results have implications for behavioural functions outside the area of money demand.

¹see Kremers and Lane (1990, 1992). Since the present paper is not a survey of the literature references are restricted to a necessary minimum.

²see Läufer (1992a, 1992b, 1995).

³See Kremers and Lane(1990), Artis et.al. (1993).

2 Two hypotheses about behavioural stability

For our purposes it is sufficient to introduce the following simplified version of an error correction model for two countries:

$$\Delta y_i = \beta_i + \gamma_i \Delta x_i + \delta_i \epsilon_{i,-1} + v_i \quad i \in \{1, 2\}. \quad (1)$$

Without index i , this equation is supposed to represent the aggregate "Europe". In a money demand context, y represents the log of money demand and x stands for the log of a determinant of money demand.⁴ v_i is a stochastic disturbance.

The cointegration regression (static long run relation) corresponding to the error-correction model (dynamic short run relation) just introduced is:

$$y_i = c_i + \gamma_i x_i + \epsilon_i \quad i \in \{1, 2\}. \quad (2)$$

In the following we shall mainly deal with

1. the size of the adjustment coefficients, δ for Europe and δ_i for country i . The speed of adjustment to equilibrium in money holdings is measured by the size of the adjustment coefficient in an error-correction model for the money demand of an economy.
2. the variances of ϵ_i and ϵ (σ_ϵ^2 , $\sigma_{\epsilon_i}^2$) and the covariance of ϵ_i and ϵ_j (σ_{ij}). The variance of the error term of a cointegration regression measures the typical size of the disequilibria (in money holdings).

In discussing the stability of the European money demand function, two issues of stability arise.

1. Adjustment speed hypothesis:

Kremers and Lane (1990, 1992) found econometrically that the speed of adjustment (δ) in the European money demand function is higher than the speed of adjustments (δ_i) in the individual European countries investigated.

2. Error variance hypothesis:

Läufer (1992a, 1995) found econometrically that the variance of the error term (σ_ϵ^2) of the European money demand function is lower than the corresponding variances (σ_i^2) for all (most) individual European countries.

In a cointegration framework it seems obvious that the two issues of stability are interlinked. *Ceteris paribus*, the higher the speed of adjustment the lower the variance of the (remaining) error terms of the cointegration regression. However, the variance of the error term (disequilibria) does not only depend on the speed of adjustment to disequilibrating shocks but also on the variance of the shocks producing those disequilibria. The variance of the error terms may therefore

⁴For the purposes of the present paper there is absolutely no need to introduce more than one determinant of money demand.

be higher in the country with the higher speed of adjustment. Thus, the two aspects of stability are not equivalent.

The issues may be sharpened by the following statements:

1. The necessary and sufficient conditions for the two kinds of stability are distinct.
2. No set of necessary and sufficient conditions is implied by the other one. One set may be fulfilled while the other one is not. The sets of conditions are mutually independent.⁵
3. The fulfillment of the conditions is an empirical issue and not a matter to be decided on a priori grounds.
4. The independence of the necessary conditions implies that the empirical issues are distinct.

Before we present necessary and sufficient conditions for the two kinds of stability, we shall clarify the meaning and relevance of the two types of stability.

3 Stability concepts underlying the hypotheses

The adjustment speed hypothesis is concerned with the speed of adjustment (δ or δ_i) to disequilibria in the (money) market. The adjustment speed indicates the time it takes on average to adjust to (absorb) a single shock that disturbs an existing equilibrium in the (money) market. It does not indicate the typical size of the shocks occurring. Under the adjustment speed hypothesis, a higher adjustment speed means a higher stability.

As long as the adjustment speed δ is not infinitely large⁶ shocks will not be absorbed instantly. Any new shock (η_t) occurring will be added to an already existing stock of incompletely absorbed shocks inherited from the past ($(1 - \delta)\epsilon_{t-1}$). Whether that stock (ϵ) is large or small depends both on the size of the shocks (η_t) that occurred over time and on the speed of adjustment (δ) (absorption).

The error variance hypothesis is concerned with σ_ϵ^2 , the *typical* size of ϵ ($= \eta_t + (1 - \delta)\epsilon_{t-1}$), which is the sum of newly arrived and incompletely absorbed shocks from the past. Under the error variance hypothesis, a lower *typical* shock size means a higher stability.

4 Relevance of the two stability concepts

The adjustment speed is relevant

⁵As we shall see, this independence of whole sets of necessary and sufficient conditions does not exclude that a necessary (but not sufficient) condition of one set implies the necessary (but not sufficient) condition of the other set.

⁶In a discrete time model the corresponding condition is: $\delta < 1$.

1. if we want to know the time required for a discretionary monetary policy measure to run a specified part of its full effect;
2. if we want to know the time required for a specific shock to be absorbed to a specified degree by the market system.

The error variance is relevant

1. if we want to know the degree of precision (reliability) with which a long run money supply target may be reached over time;
2. if we want to know how much interest rate instability is implied by money supply targetting.

These listings are not exhaustive but illustrative. They tend to indicate that the adjustment speed hypothesis is relevant for discretionary monetary policy while the error variance hypothesis is relevant for rule-oriented behaviour of monetary policy.

5 Outlook and restrictions of the analysis

We shall demonstrate necessary and sufficient conditions for the two kinds of stability. In this demonstration it does not matter whether we deal with a money demand function or any other behavioural function. All that matters is the composition of the error term of the aggregate (European) behavioural function. That error term is shown to be a weighted average of the country specific behavioural error terms and we shall be able to apply some ideas from elementary portfolio theory. In addition, the word "Europe" is insignificant for the points at issue.

6 Conditions for lower error variance

We shall demonstrate the error variance hypothesis in a Europe of two countries. The behaviour (money demand) of country i will be described by a simplified nonlinear stochastic function:

$$Y_i = C_i X_i^\gamma (1 + \epsilon_i) \quad i \in \{1, 2\} \quad (3)$$

which can be transformed into a linear regression

$$y_i = c_i + \gamma_i x_i + \epsilon_i \quad i \in \{1, 2\} \quad (4)$$

where $y_i = \ln Y_i$, $x_i = \ln X_i$, and $c_i = \ln C_i$. ϵ_i is the error term of country i with variance σ_i^2 . σ_{ij} is the covariance of country i 's error term (ϵ_i) with the error term of country j (ϵ_j). In case of money demand functions, Y_i is (real) money demand in country i and X_i represents the explicit determinants of money demand in country i . The country specific behavioural functions may be aggregated to obtain a European function.

The nonlogged functions have to be converted into a common currency before they can be added. This conversion is assumed to have been implemented but it is not made explicit formally in the following definitions:

$$Y \equiv Y_1 + Y_2, \quad (5)$$

$$X \equiv X_1 + X_2, \quad (6)$$

$$cX^\gamma \equiv c_1 X_1^{\gamma_1} + c_2 X_2^{\gamma_2}, \quad (7)$$

$$\alpha_i = \frac{c_i X_i^{\gamma_i}}{c_1 X_1^{\gamma_1} + c_2 X_2^{\gamma_2}} \quad i \in \{1, 2\}, \quad (8)$$

$$\epsilon \equiv \alpha_1 \epsilon_1 + \alpha_2 \epsilon_2. \quad (9)$$

α_i is the relative share of the (conditional expected value of the) demand for money in country i in the (conditional expected value of the) European money demand. These definitions imply:

$$Y = (c_1 X_1^{\gamma_1} + c_2 X_2^{\gamma_2})[1 + (\alpha_1 \epsilon_1 + \alpha_2 \epsilon_2)], \quad (10)$$

$$Y = cX^\gamma(1 + \epsilon), \quad (11)$$

$$y = \ln c + \gamma x + \epsilon. \quad (12)$$

$\epsilon (= \alpha_1 \epsilon_1 + \alpha_2 \epsilon_2)$ is the European error term with variance σ_ϵ^2 . ϵ is a weighted average of national error terms and resembles the composition of an average rate of return familiar from elementary portfolio theory (case of two assets).

Error variance hypothesis: $\sigma_\epsilon < \sigma_i$ for all $i \in \{1, 2\}$.

In order to have a lower variance for the error terms in Europe than in all individual countries the following conditions are *necessary and sufficient*:

1. The coefficients (b_i) of the regressions of the error terms (ϵ_i on ϵ_j) have to be smaller than 1:

$$b_i \equiv \frac{\sigma_{ij}}{\sigma_j^2} < 1 \quad i, j, \in \{1, 2\}, i \neq j. \quad (13)$$

2. The actual α_i must be sufficiently close to the (globally) variance minimizing shares α_i^M familiar from portfolio theory:

$$\alpha_i^M = \frac{\sigma_j^2 - \sigma_{ij}}{\sigma_1^2 + \sigma_2^2 - 2\sigma_{12}} \quad i, j \in \{1, 2\}, i \neq j. \quad (14)$$

The first condition⁷ implies that the variance minimizing shares (α_i^M) are positive and smaller than 1 ($0 < \alpha_i^M < 1$). This excludes variance minimizing shares which are equal to one, equal to zero, negative or larger than one. The

⁷The first condition may also be expressed as a requirement for the size of the correlation coefficient between the error terms. The correlation coefficient has to be smaller than:

$$\text{Min}\left(\frac{\sigma_1}{\sigma_2}, \frac{\sigma_2}{\sigma_1}\right).$$

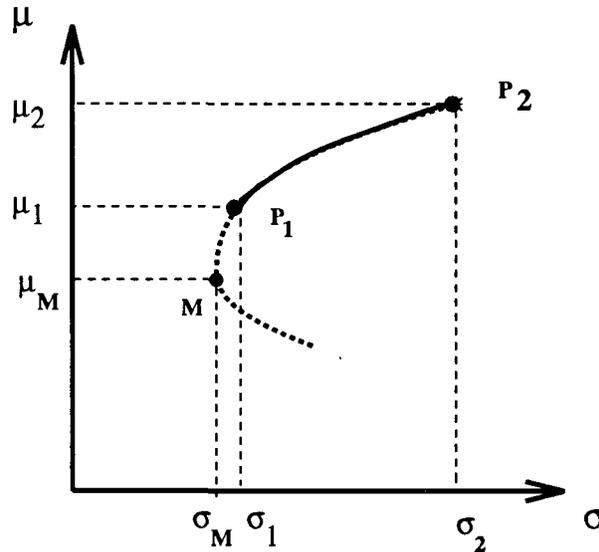
second condition requires sufficient nearness of actual and variance minimizing shares. The second condition is an effective restriction only if $\sigma_1^2 \neq \sigma_2^2$. If $\sigma_1^2 = \sigma_2^2$, then the second condition is automatically satisfied. Figures 1, 2, 3, and 4 serve to illustrate the significance of these conditions.

Since the European error term is a weighted average of the country specific error terms similar to the rates of return on assets in portfolio theory⁸, the μ, σ -diagram of portfolio theory is applicable.⁹

In figures 1, 2, 3 and 4, the solid parts of the loci refer to points where the α_i satisfy the condition $0 \leq \alpha_i \leq 1$.

μ, σ - Diagrams For Error Variance Hypothesis

Figure 1: The general case violating condition 1



⁸For optical reasons in the figures the expected values of ϵ_i is taken to be c_i . These again are assumed to be different and positive $c_2 > c_1 > 0$. If we would draw the figures using the true zero values then the hyperbola would collapse into a straight line.

⁹The opportunity locus in the μ, σ -diagram of portfolio theory is a geometric representation of a function $\mu = f(\sigma)$. Such a function is implicit in the definition of the variance and the mean of the European error term, $\epsilon = \alpha_1 \epsilon_1 + \alpha_2 \epsilon_2$:

$$\begin{aligned} \sigma_\epsilon^2 &= \alpha_1^2 \sigma_1^2 + \alpha_2^2 \sigma_2^2 + 2\alpha_1 \alpha_2 \sigma_1 \sigma_2, \\ \mu_\epsilon &= \alpha_1 \mu_1 + \alpha_2 \mu_2, \\ 1 &= \alpha_1 + \alpha_2. \end{aligned}$$

The covariance structure of the error terms determines the shape of the opportunity locus.

Figure 2: A borderline case violating condition 1

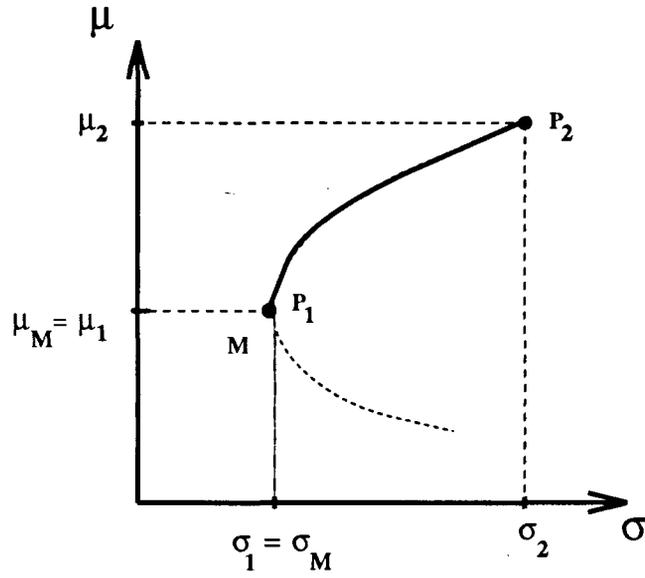


Figure 3: Condition 1 satisfied, condition 2 not effectively constraining

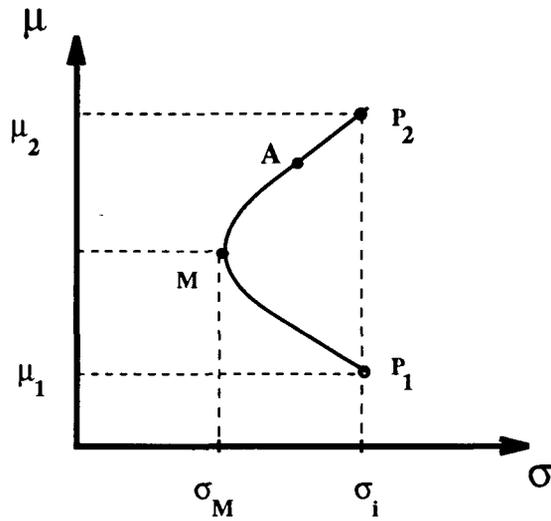
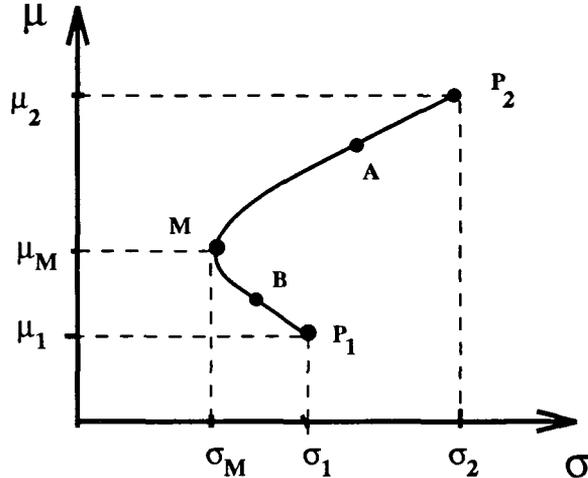


Figure 4: Condition 1 satisfied, condition 2 effectively constraining



In figures 1 and 2, the shares associated with M, the global minimum variance point, cannot both be positive. In fact, in figure 1, α_1^M is larger than 1 and α_2^M is negative. In figure 2, α_1^M is equal to 1 and α_2^M is equal to 0. In figures 1 and 2, points from the interior of the solid line connecting P_1 and P_2 represent positive shares. No point from that interior can have a σ value equal to or lower than σ_1 , which, by assumption, is the minimum of the σ_i . Condition 1 excludes situations as described in figures 1 and 2.

In figure 3, we consider the special case¹⁰ $\sigma_1^2 = \sigma_2^2$. In this case, any point with positive (relative) shares is located to the left of a vertical line through the minimum of the σ_i and is close enough to point M. In this case, condition 2 is no effective restriction.

In figure 4, all points (of the locus) lying on the left of a vertical line through σ_1 satisfy the second condition. Point B lies to the left of the vertical line through the minimum of the σ_i while point A does not. Therefore, point B is while point A is not sufficiently close to point M as required by the second condition. In this case both conditions are effectively constraining.¹¹

7 Conditions for higher adjustment speed

The discussion of adjustment speed arises around an error-correction specification of money demand which we have already introduced with equation (1).

¹⁰However, condition 2 does not require $\sigma_1^2 = \sigma_2^2$

¹¹Given that the variance reduction may be explained in terms of portfolio theory it may be called a *portfolio diversification effect*.

Weighting by the relative shares, α_i , and adding the two equations (1), we obtain the European aggregate:

$$\begin{aligned}\alpha_1 \Delta y_1 + \alpha_2 \Delta y_2 &= (\alpha_1 \beta_1 + \alpha_2 \beta_2) \\ &+ (\alpha_1 \gamma_1 \Delta x_1 + \alpha_2 \gamma_2 \Delta x_2) \\ &+ (\alpha_1 \delta_1 \epsilon_1 + \alpha_2 \delta_2 \epsilon_2) \\ &+ (\alpha_1 v_1 + \alpha_2 v_2)\end{aligned}\quad (15)$$

As a *direct* specification for the European error-correction model we have instead:

$$\Delta y = \beta + \gamma \Delta x + \delta \epsilon + v \quad (16)$$

with

$$\epsilon = \alpha_1 \epsilon_1 + \alpha_2 \epsilon_2. \quad (17)$$

The α 's and the ϵ 's have the same meaning as in the previous section for the error variance hypothesis.

Adjustment speed hypothesis (Kremers and Lane): $\delta > \delta_i$ for all $i \in \{1, 2\}$.

In order to have an adjustment speed which is higher in Europe than in any single European country, the following conditions are *necessary and sufficient*:

1. The country specific adjustment speeds, δ_i and δ_j , must be different; without loss of generality: $\delta_1 > \delta_2$.
2. The regression coefficient b_i for the country specific error terms must be sufficiently negative:

$$0 < \frac{\alpha_2 (\frac{\delta_2}{\delta_1} + 1)}{2\alpha_1} < -\frac{\sigma_{12}}{\sigma_2^2} \equiv -b_i. \quad (18)$$

Both conditions are necessary. Together they are also sufficient.

8 Proof of the conditions for higher adjustment speed

Our definitions and equations (15) and (16) imply the following equation:

$$\delta_1 \alpha_1 \epsilon_1 + \delta_2 \alpha_2 \epsilon_2 = \delta \epsilon. \quad (19)$$

By means of a regression equation for the error terms (ϵ_1 and ϵ_2):

$$\epsilon_1 = \frac{\sigma_{12}}{\sigma_2^2} \epsilon_2 + u_1, \quad (20)$$

where

$$\text{cov}(\epsilon_2, u_1) = 0, \quad (21)$$

equation (19) can be written as:

$$\alpha_1 \delta_1 \left(\frac{\sigma_{12}}{\sigma_2^2} \epsilon_2 + u_1 \right) + \delta_2 \alpha_2 \epsilon_2 = \delta \left[\alpha_1 \left(\frac{\sigma_{12}}{\sigma_2^2} \epsilon_2 + u_1 \right) + \alpha_2 \epsilon_2 \right]. \quad (22)$$

Computing variances of both sides of (22) we obtain:

$$\begin{aligned} \alpha_1^2 \delta_1^2 \frac{\sigma_{12}^2}{(\sigma_2^2)^2} \sigma_2^2 + \alpha_1^2 \delta_1^2 \sigma_{u_1}^2 + [\alpha_2^2 \delta_2^2 \sigma_2^2 + 2\alpha_1 \delta_1 \alpha_2 \delta_2 \frac{\sigma_{12}}{\sigma_2^2} \sigma_2^2] &= \\ \delta^2 \left(\alpha_1^2 \frac{\sigma_{12}^2}{(\sigma_2^2)^2} \sigma_2^2 + \alpha_1^2 \sigma_{u_1}^2 + [\alpha_2^2 \sigma_2^2 + 2\alpha_1 \alpha_2 \frac{\sigma_{12}}{\sigma_2^2} \sigma_2^2] \right) &> \\ \delta_1^2 \left(\alpha_1^2 \frac{\sigma_{12}^2}{(\sigma_2^2)^2} \sigma_2^2 + \alpha_1^2 \sigma_{u_1}^2 + [\alpha_2^2 \sigma_2^2 + 2\alpha_1 \alpha_2 \sigma_{12}] \right). & \end{aligned} \quad (23)$$

Without loss of generality we may assume $\delta_1 \geq \delta_2 (> 0)$. The inequality part of (23) then expresses the adjustment speed hypothesis of Kremers and Lane. From the square bracket terms in (23) we find:

$$[\alpha_2^2 \delta_2^2 \sigma_2^2 + 2\alpha_1 \delta_1 \alpha_2 \delta_2 \frac{\sigma_{12}}{\sigma_2^2} \sigma_2^2] > \delta_1^2 [\alpha_2^2 \sigma_2^2 + 2\alpha_1 \alpha_2 \sigma_{12}]. \quad (24)$$

Rearranging terms in (24) we obtain:

$$(\delta_2^2 - \delta_1^2) \alpha_2^2 \sigma_2^2 > 2\alpha_1 \alpha_2 \sigma_{12} \delta_1 (\delta_1 - \delta_2). \quad (25)$$

If $\delta_1 = \delta_2$ then the last inequality cannot hold. Thus, having assumed $\delta_1 \geq \delta_2 (> 0)$, the Kremers and Lane hypothesis implies $\delta_1 > \delta_2 (> 0)$ and is equivalent to the following inequality:

$$\frac{\frac{\delta_1 + \delta_2}{2}}{\delta_1} \frac{\alpha_2}{\alpha_1} < -\frac{\sigma_{12}}{\sigma_2^2} \equiv -b_i. \quad (26)$$

From $\alpha_i, \delta_i, \sigma_i^2 > 0$ it follows that $\sigma_{12} < 0$ is necessary. In order to prove sufficiency the steps of this proof merely need to be done in reverse. (qed).

9 Comparing the two sets of conditions

Each set of necessary and sufficient conditions has two parts. In both sets there is a part with regression coefficients. But the condition of a negative regression coefficient, $b_i < 0$ is stronger than the requirement of a regression coefficient smaller than 1 ($b_i < 1$). The conditions are different even in the parts where they look similar. Thus, the two sets of necessary and sufficient conditions are mutually independent in the following sense: If the necessary and sufficient conditions for a higher adjustment speed in Europe are satisfied then the country shares (α_i) may still be to far off the (globally) variance minimizing values (α_i^M). On the other hand, if the necessary and sufficient conditions for a lower European error variance are satisfied then the country specific adjustment

speeds may not be different or the regression coefficient between the country specific error terms may not be negative or may be so only insufficiently.

From these considerations we see that no set of necessary and sufficient conditions is implied by the other one. In this sense they are mutually independent.¹² Therefore the two aspects of stability are distinct.

10 Currency substitution versus portfolio diversification

The distinction between adjustment speed and error variance can also be discussed in terms of a *currency substitution effect* versus a *portfolio diversification effect*.

A typical statement which we would like to discuss may be paraphrased as follows: "The (higher) stability of the European money demand function is a matter of currency substitution".¹³ In this context, a negative covariance ($\sigma_{12} < 0$) between the error terms for the (two) countries has been interpreted as a sign of currency substitution.¹⁴ We do not want to dispute this *interpretation* of the covariance term but the view that currency substitution is responsible (necessary) for a higher stability of the European money demand function. We start by considering the following condition

$$\text{var}(\epsilon_1 + \epsilon_2) = \sigma_1^2 + \sigma_2^2 + 2\sigma_{12} < \text{Min}(\sigma_1^2, \sigma_2^2) \quad (27)$$

from which it is clear that we necessarily have

$$\sigma_{12} < 0. \quad (28)$$

While it is correct to say that the variance of an unweighted sum of two error terms may only be smaller than the minimum of the individual error variances if the covariance of the two error terms is sufficiently negative it may be false to start with an unweighted sum in the first place. As a matter of fact, our aggregation procedures have shown that both the error term in the static European cointegration regression and the correction error in the dynamic European adjustment equation lead to *weighted* sums of error terms. And as soon as we switch from unweighted to weighted sums of error terms the situation changes critically.

In the static European cointegration regression the error term is a *weighted* sum of country specific error terms. It has a structure known from average rates of return in portfolio theory. Therefore, any variance reduction can be identified

¹²The fact that the necessary part of one set of conditions implies the necessary part of the other set does not establish an equivalence or implication between the complete sets of necessary and sufficient conditions.

¹³see, e.g., Kremers and Lane (1990, p. 781), Artis et.al. (1993, p. 251).

¹⁴This interpretation is linked to the work of McKinnon (1982), Spinelli (1983) and Bekx and Tullio (1989).

as a portfolio diversification effect which does not require currency substitution (negative covariances). Specifically, the inequality

$$\sigma_\epsilon^2 = \text{var}(\alpha_1\epsilon_1 + \alpha_2\epsilon_2) = \alpha_1^2\sigma_1^2 + \alpha_2^2\sigma_2^2 + 2\alpha_1\alpha_2\sigma_{12} < \text{Min}(\sigma_1^2, \sigma_2^2) \quad (29)$$

does not imply currency substitution ($\sigma_{12} < 0$). Currency substitution is a much too strong requirement. The variance reduction phenomenon (see *error variance hypothesis*) is clearly¹⁵ a consequence of the aggregate (European) money demand function forming a “portfolio” of country specific money demand functions.¹⁶ This portfolio character is responsible for the weighting of the error terms.

Considering the *adjustment speed hypothesis*, it is clear that currency substitution ($\sigma_{12} < 0$) is a necessary but not a sufficient condition. Currency substitution must be sufficiently strong for the adjustment speed hypothesis to be true. But even a sufficiently strong currency substitution alone would not do. It is also necessary that the countries differ in adjustment speed.

Thus, we find that currency substitution is necessary but not sufficient for the *adjustment speed hypothesis*, while it is neither necessary nor sufficient for the *error variance hypothesis*. Positions which conflict with these results are likely to be explainable by a non-distinction or confusion of weighted and unweighted sums of error terms. The use of unweighted sums of error terms may be the outcome of an improper aggregation procedure.

11 The role of aggregation

It is hard to believe that the simple portfolio-theoretic idea behind the error variance hypothesis or the effect of weighting error terms instead of using unweighted sums or averages should be absent from the aggregation literature. In order to illustrate this absence we have chosen to reproduce sample statements from that literature which have some affinity to the error variance hypothesis.

In Theil (1965), a standard reference for the aggregation problem in economics, we can read the following statement: “*In general the second moment about zero of a macrodisturbance is larger than the variance of the sum of the corresponding microdisturbances.* Exceptions to this rule (such that ‘larger than’ must be replaced by ‘equal to’) can, of course, always be obtained....”¹⁷ In our

¹⁵Here we argue on apriori grounds. However, empirical work supports this view. See Läufer (1995).

¹⁶If we speak of a portfolio diversification effect or a portfolio of country specific money demand functions this should not suggest the idea that there is any individual or country holding more than one kind of currency. If Kremers and Lane say “In addition to currency substitution, international portfolio diversification (of which currency substitution is a special case) ...” then they have in mind individuals or countries which hold a portfolio with more than one currency. We use the term portfolio diversification (effect) in order to emphasize a structural analogy between weighted sums of rates of return and weighted sums of error terms.

¹⁷See the seminal monograph of H. Theil (1965, p. 115). Emphasis already in H. Theil.

terms, Theil's position may be expressed by the following inequality:

$$\text{var}(\sum \epsilon_i) \leq \text{var}(\epsilon). \quad (30)$$

Grunfeld and Griliches (1960) deal with the reliability of predictions of a macro variable obtained by two different methods: (a) the "aggregate" method, whereby the macro variable is predicted from a linear macro relation and (b) the "composite" or disaggregated method, whereby the values of individual variables are predicted from micro relations and the results are added together. In a framework similar to Theil's, these authors demonstrate the possibility of the second method to have higher predictive reliability. Grunfeld-Griliches are interested in the conditions under which

$$\text{var}(\sum \epsilon_i) < \text{var}(\epsilon), \quad (31)$$

where ϵ_i and ϵ now represent prediction errors. The inequality of Grunfeld and Griliches is entirely consistent with Theil's statement.¹⁸

Obviously the error variance hypothesis:

$$\text{var}(\epsilon) < \text{var}(\epsilon_i), \quad i = 1, \dots, n. \quad (32)$$

is not only *not implied* by these hypotheses from linear aggregation theory but it is even *in conflict* with them¹⁹. This conflict may be "solved" by noting the difference between the aggregation procedures involved.

The aggregation procedure underlying the statements of Theil et. al. is linear. In linear aggregation theory linear micro relations are added using weights which apply equally (symmetrically) to all variables subject to aggregation, including the error terms.

In our discussion of the European money demand function the regression variables for Europe as a whole were not derived by summing up the logs of country specific variables but by taking the log of the sum of unlogged country specific variables. This is a nonlinear aggregation procedure.²⁰ On the other hand, the country specific error terms were aggregated into a European error term by forming a weighted average. Thus, the aggregation procedure applied to the error terms is different from the one applied to the other variables of the demand functions. Due to this asymmetry and due to the nonlinearity of aggregation (with respect to the non-error variables) it should not come as a surprise that the variance hypothesis is not included in and is even in conflict with classical results of linear aggregation theory.

¹⁸For the present discussion, Green (1964) offers nothing beyond a recount and critique of the positions of Theil and Grunfeld-Griliches.

¹⁹To see the conflict consider $\text{var}(\epsilon) = \text{var}(\epsilon_1 + \epsilon_2) = \sigma_1^2 + \sigma_2^2 + 2\sigma_{12}$. In case $\rho_{12} = -1$ and $2\sigma_2 < \sigma_1$ we have $\sigma_2^2 < (\sigma_1 - \sigma_2)^2 = \text{var}(\epsilon_1 + \epsilon_2) = \text{var}(\epsilon)$. The implied inequality $\sigma_2^2 < \text{var}(\epsilon)$ seems to contradict the error variance hypothesis.

²⁰More precisely, the logs of country specific variables are first unlogged and then summed. The resulting European sum then is logged again. This amounts to a nonlinear transformation (aggregation).

12 Summary and conclusion

In the literature on the stability of the European money demand function we find both an *adjustment speed* hypothesis and an *error variance* hypothesis. According to the adjustment speed hypothesis equilibrium is reached faster for European money demand than for money demand in individual countries. According to the error variance hypothesis the *typical* size of the disequilibria (as measured by the variance of the error terms of static long run money demand) is lower in Europe than in any individual country. With respect to these hypotheses the results of the present paper are as follows.

Firstly, we have found that the *adjustment speed hypothesis* may hold while the *error variance hypothesis* is false and that the error variance hypothesis may hold while the adjustment speed hypothesis is false. These results are not at all conditioned by the fact that we were interested in money demand functions. They apply to other behavioural functions as well.

Secondly, we have found that the adjustment speed hypothesis as applied to money demand functions is relevant for discretionary monetary policy while the error variance hypothesis is relevant for rule-oriented monetary policy.

Thirdly, in the literature²¹ the stability of the European money demand function has been linked to the phenomenon of currency substitution. Our results imply, firstly, that currency substitution ($\sigma_{12} < 0$) is not relevant for the error variance hypothesis but only for the adjustment speed hypothesis and, secondly, that currency substitution, even if sufficiently strong, is not a sufficient condition for the adjustment speed hypothesis to hold. The countries involved must also have different adjustment speeds.

Fourthly, in contrast to the prevailing literature on European money demand stability which emphasizes the idea of currency substitution we have pointed to the working of a portfolio diversification effect that is not linked to currency substitution and is relevant for the error variance hypothesis but not for the adjustment speed hypothesis. The term "portfolio diversification effect" is not used to suggest that there is any individual or country holding more than one currency but is used in order to emphasize a structural analogy between weighted sums of rates of return in portfolio theory and weighted sums of error terms in properly aggregated European money demand functions. Since it is easy to imagine a future European central bank as holding a portfolio of national money demand functions the term "portfolio diversification" also has some descriptive meaning.

Finally, we have shown that the content of the error variance hypothesis cannot be derived from linear aggregation theory.

²¹see, e.g., Kremers and Lane (1990, p. 781), Artis et.al. (1993, p. 251).

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